Advanced Superconducting Devices for High-Performance Computing

Rapid Single Flux Quantum (RSFQ) digital circuits are based on quantized voltage pulses produced by Josephson junctions. The superconducting flux quantum is 2.07 mV-ps and the natural voltage scale of Josephson junctions can be several mV. Pulses of ps duration and circuit clock speeds of hundreds of GHz have been demonstrated without reaching physical limits. RSFQ is the only demonstrated approach to computation that is capable of such speeds. For that reason, RSFQ logic is integral to plans for general-purpose computers with petaflops performance. Realizing the full potential of RSFQ technology will require considerable improvements in superconducting chip fabrication technology, including the development of deep-submicrometer, overdamped Josephson junctions having the highest possible critical current-resistance product. This can be accomplished only by substantially increasing the ratio of critical current density to specific capacitance of the junctions. In this talk I will discuss the behavior of high critical current density Josephson junctions, the issues associated with obtaining the ultimate performance available from Nb-based RSFQ circuits and the possibility of circuits based on intrinsically faster materials.